Analysis of Mechanisms for an Autonomous Robot that has the Capability to Extinguish Two Target Lights

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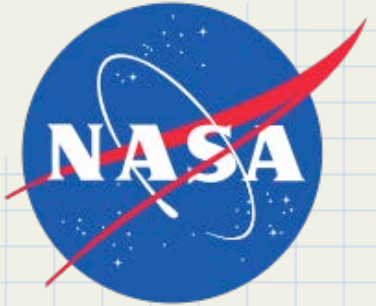
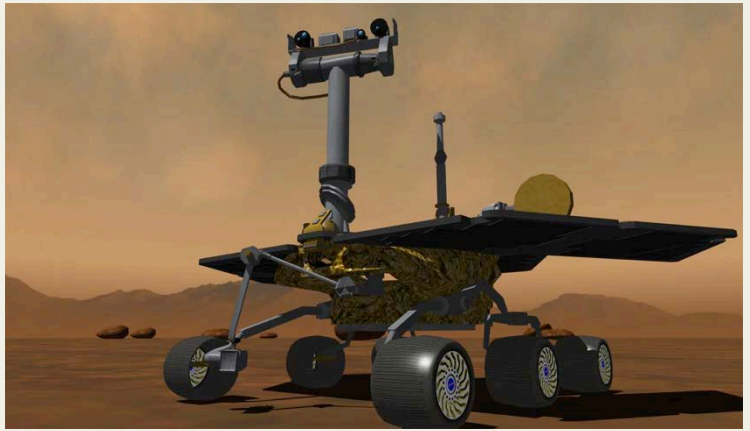


What is an Autonomous Robot?

- Robots capable of performing tasks without human assistance
- Typically programmed to accomplish a specific task
- Commonly used in industrial areas
  - Intelligent robots used for exploration
    - Mars Rover

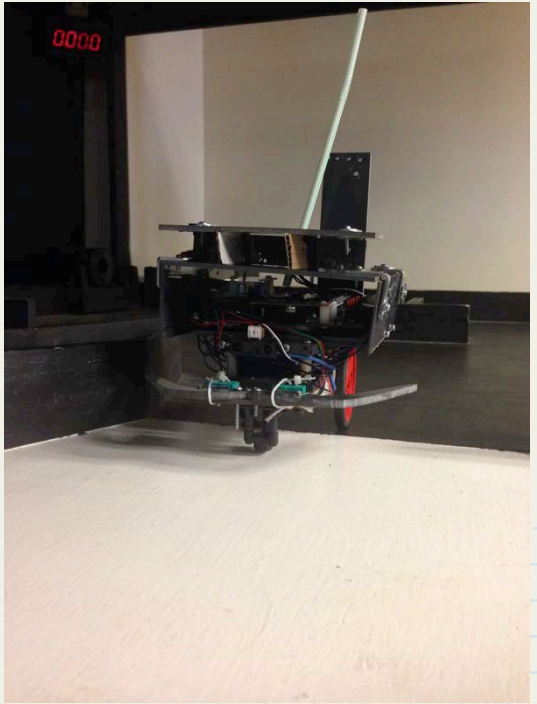


Types of Autonomous Robots

- Programmable
- Non-programmable
- Adaptive
- Intelligent

Objectives

- Construct and design a simple autonomous robot
  - Extinguish two target lights in less than 35 seconds in a 4’ x 8’ Arena
- Obtain deeper understanding of mechanisms of an autonomous robot.
- Win robot competition



The Competition

- Two robots placed on opposite sides of arena
- Robots compete to extinguish target lights in enemy territory
- Respond to wooden obstacles

Project Management

- Engineering has a meticulous, methodical nature
  - Planning is crucial
    - Keeps track of multiple tasks
    - Creates a hierarchy for task prioritization
  - “Plans are nothing; planning is everything.” - Dwight D. Eisenhower
    - Plans don’t follow through perfectly
    - Process is crucial

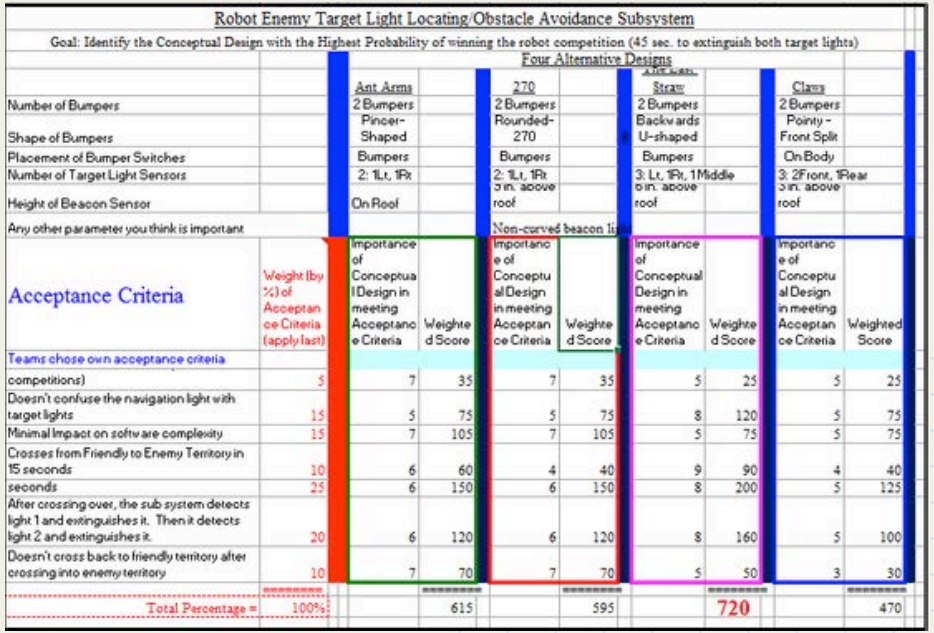
Gantt Chart

- Grouped Tasks into categories
  - Hardware Activities, Software Activities, Functionality Tests, etc.
- Deadlines were given to each subtask
  - Accounted for delays

Task ID	Task Name	Sub-task Name	Duration (hours)	Start Date	End Date	Predecessor	Resource Initials
1	House Gantt Chart Tutotial		4	6/15/15	6/22/15	0	JSM, MF, SS
2	Generating and Evaluating Concepts		2	6/16/15	6/23/15	0	JSM, MF, SS
3	Start Robot Project		1			1	
4		Overview of WBS and Major Milestones	1	6/16/15	6/22/15	0	JSM, MF, SS
5	UPDATE THIS GANTT CHART		2	6/22/05	6/22/15		MF, SS
6	System Design Complete (Sensor Suite Defined)		0	6/16/15	6/23/15	2,4	MF, SS
7	Major Hardware Activities		51	6/16/15	7/17/15		
8		Robot Chassis Construction	2	6/16/15	7/17/15	5	SS
9		Basic Chasis, Arduino, Motors Mounted	1	6/16/15	7/10/15	8	MF
10		Soldering Clinic	2	7/6/15	7/6/15	6	SS
11		Soldering Practice	4	7/6/15	7/6/15	10	SS
12		Construct FSM	2	7/7/15	7/7/15	11	MF, SS
13		Design/Construct Bumpers	12	7/8/15	7/9/15	9	SS
14		Calibrate Target Lights on Arduino	12	7/10/15	7/13/15	13	MF, SS
15		Write Mechanical Report Section	8	7/13/15	7/14/15	9, 10, 11, 13	MF, SS
16		Write Electrical Report Section	8	7/14/15	7/17/15	12,14,15	MF, SS

Alternative Design Matrix

- 4 preliminary conceptual designs were created
- Each design was scored based on criteria
  - Feasibility, speed, longevity



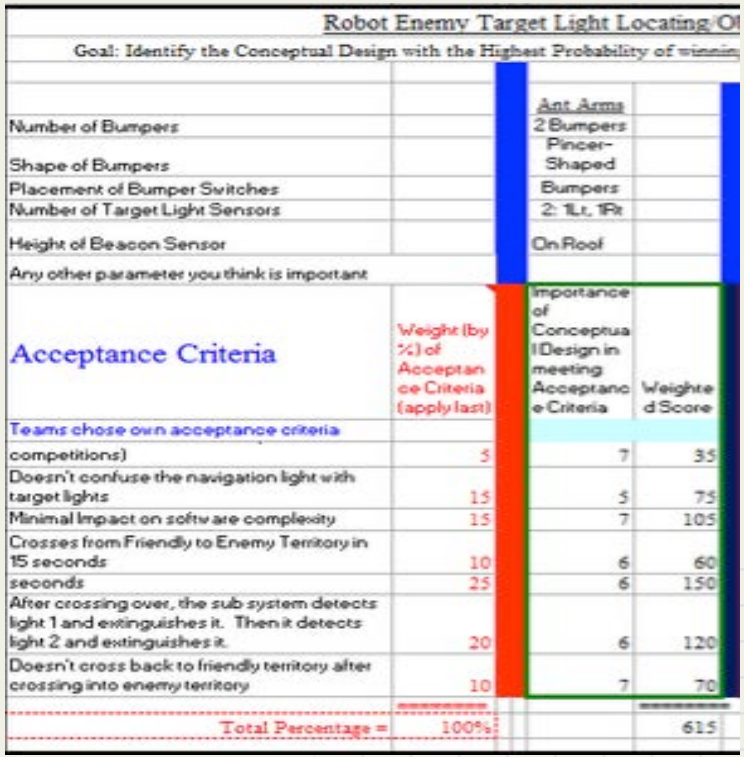
Robot Enemy Target Light Locating/Obstacle Avoidance Subsystem

Goal: Identify the Conceptual Design with the Highest Probability of winning the robot competition (45 sec. to extinguish both target lights)

		Four Alternative Designs							
		Ant Arms		270		Straw		Claws	
Number of Bumpers		2 Bumpers		2 Bumpers		2 Bumpers		2 Bumpers	
Shape of Bumpers		Pincer-Shaped		Rounded-270		Backwards U-shaped		Pointy - Front Split	
Placement of Bumper Switches		Bumpers		Bumpers		Bumpers		On Body	
Number of Target Light Sensors		2: 1Lt, 1Rt		2: 1Lt, 1Rt		3: Lt, 1Rt, 1Middle		3: 2Front, 1Rear	
Height of Beacon Sensor		On Roof		3 in. above roof		6 in. above roof		3 in. above roof	
Any other parameter you think is important				Non-curved beacon lig					
Acceptance Criteria	Weight (by %) of Acceptance Criteria (apply last)	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score
Teams chose own acceptance criteria									
competitions)	5	7	35	7	35	5	25	5	25
Doesn't confuse the navigation light with target lights	15	5	75	5	75	8	120	5	75
Minimal impact on software complexity	15	7	105	7	105	5	75	5	75
Crosses from Friendly to Enemy Territory in 15 seconds	10	6	60	4	40	9	90	4	40
seconds	25	6	150	6	150	8	200	5	125
After crossing over, the sub system detects light 1 and extinguishes it. Then it detects light 2 and extinguishes it.	20	6	120	6	120	8	160	5	100
Doesn't cross back to friendly territory after crossing into enemy territory	10	7	70	7	70	5	50	3	30
Total Percentage =	100%		615		595		720		470

Preliminary Conceptual Designs

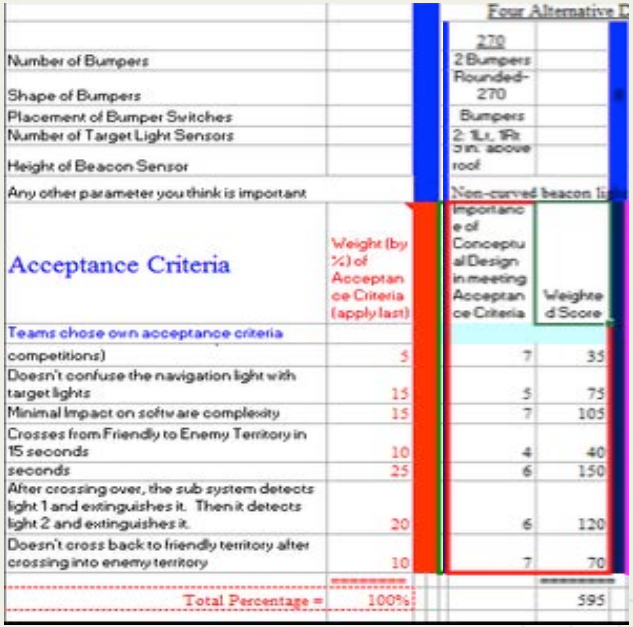
- Ant Arms
  - 2 Bumper Switches on Left and Right side of robot
  - Pincer-shaped bumpers
  - 2 Target Light Sensors
    - Left and Right
  - 1 Beacon Light Sensor
    - Placed on center platform
    - Directly on robot



Robot Enemy Target Light Locating/O			
Goal: Identify the Conceptual Design with the Highest Probability of winnin			
		Ant Arms	
Number of Bumpers		2 Bumpers	
Shape of Bumpers		Pincer-Shaped	
Placement of Bumper Switches		Bumpers	
Number of Target Light Sensors		2: 1Lt, 1Rt	
Height of Beacon Sensor		On Roof	
Any other parameter you think is important			
Acceptance Criteria	Weight (by %) of Acceptance Criteria (apply last)	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score
Teams chose own acceptance criteria			
competitions)	5	7	35
Doesn't confuse the navigation light with target lights	15	5	75
Minimal Impact on software complexity	15	7	105
Crosses from Friendly to Enemy Territory in 15 seconds	10	6	60
seconds	25	6	150
After crossing over, the sub system detects light 1 and extinguishes it. Then it detects light 2 and extinguishes it.	20	6	120
Doesn't cross back to friendly territory after crossing into enemy territory	10	7	70
Total Percentage =	100%		615

Preliminary Conceptual Designs

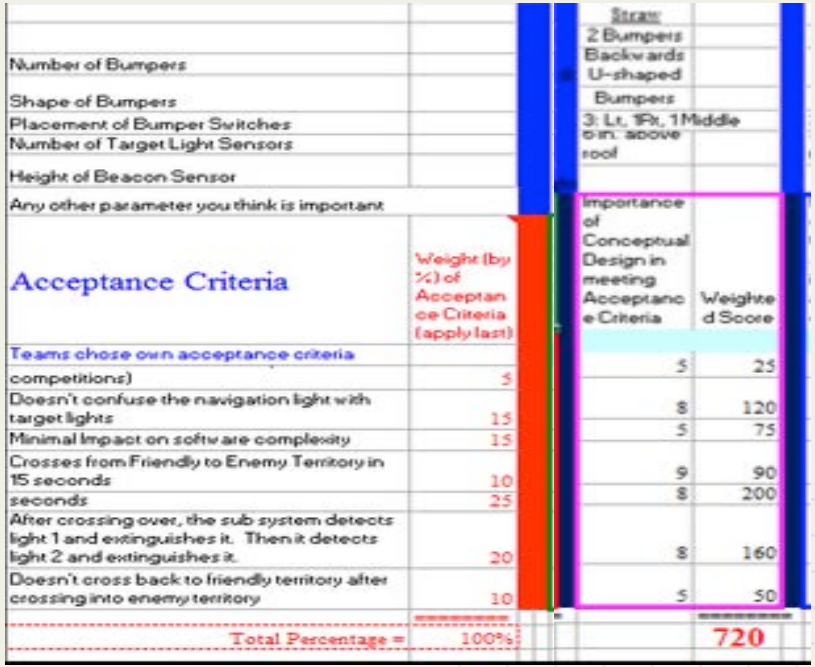
- 270
  - 2 Bumper Switches on Left and Right side of robot
  - Rounded 270-degree bumpers
  - 3 Target Light Sensors
    - Left, Right, and Rear of robot
  - 1 Beacon Light Sensor
    - Placed on center platform
    - 3 inches above robot



		Four Alternative D
		270
Number of Bumpers		2 Bumpers
Shape of Bumpers		Rounded-270
Placement of Bumper Switches		Bumpers
Number of Target Light Sensors		2: 1Lt, 1Rt
Height of Beacon Sensor		3 in. above roof
Any other parameter you think is important		Non-curved beacon li
Acceptance Criteria	Weight (by %) of Acceptance Criteria (apply last)	Importance of Conceptual Design in meeting Acceptance Criteria / Weighted Score
Teams chose own acceptance criteria		
competitions)	5	7 35
Doesn't confuse the navigation light with target lights	15	5 75
Minimal Impact on software complexity	15	7 105
Crosses from Friendly to Enemy Territory in 15 seconds	10	4 40
seconds	25	6 150
After crossing over, the sub system detects light 1 and extinguishes it. Then it detects light 2 and extinguishes it.	20	6 120
Doesn't cross back to friendly territory after crossing into enemy territory	10	7 70
Total Percentage =	100%	595

Preliminary Conceptual Designs

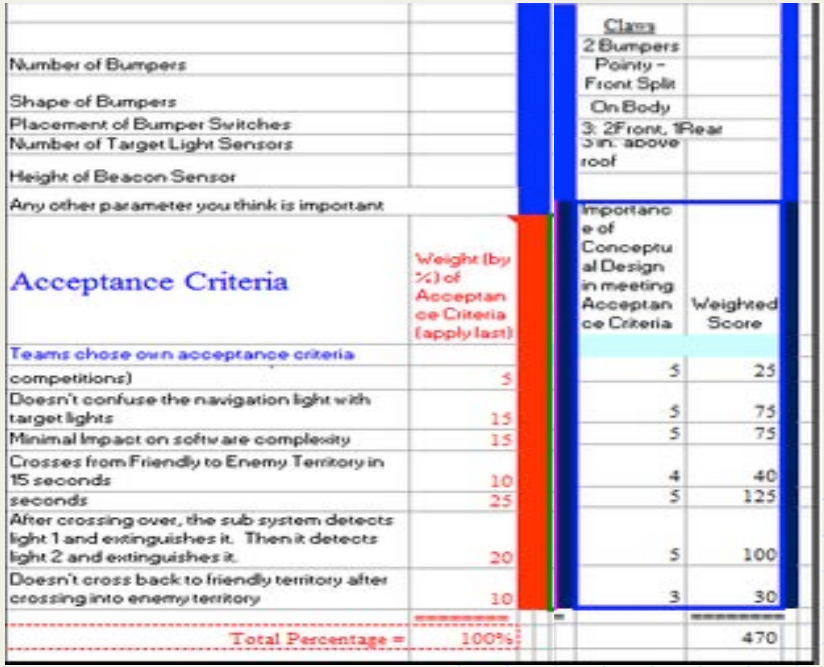
- The Last Straw
  - 2 Bumper Switches on Left and Right side of robot
  - U-Shaped Bumpers (2-piece)
  - 3 Target Light Sensors
    - Left, Right, and Center of robot
  - 1 Beacon Light Sensor
    - Placed on center platform
    - 6 inches above robot



		Straw:
		2 Bumpers
Number of Bumpers		Backwards
Shape of Bumpers		U-shaped Bumpers
Placement of Bumper Switches		3: Lt, 1Ft, 1Middle
Number of Target Light Sensors		6 in. above roof
Height of Beacon Sensor		
Any other parameter you think is important		
Acceptance Criteria	Weight (by %) of Acceptance Criteria (apply last)	Importance of Conceptual Design in meeting Acceptance Criteria / Weighted Score
Teams chose own acceptance criteria		
competitions)	5	5 / 25
Doesn't confuse the navigation light with target lights	15	8 / 120
Minimal Impact on software complexity	15	5 / 75
Crosses from Friendly to Enemy Territory in 15 seconds	10	9 / 90
seconds	25	8 / 200
After crossing over, the sub system detects light 1 and extinguishes it. Then it detects light 2 and extinguishes it.	20	8 / 160
Doesn't cross back to friendly territory after crossing into enemy territory	10	5 / 50
Total Percentage =	100%	720

Preliminary Conceptual Designs

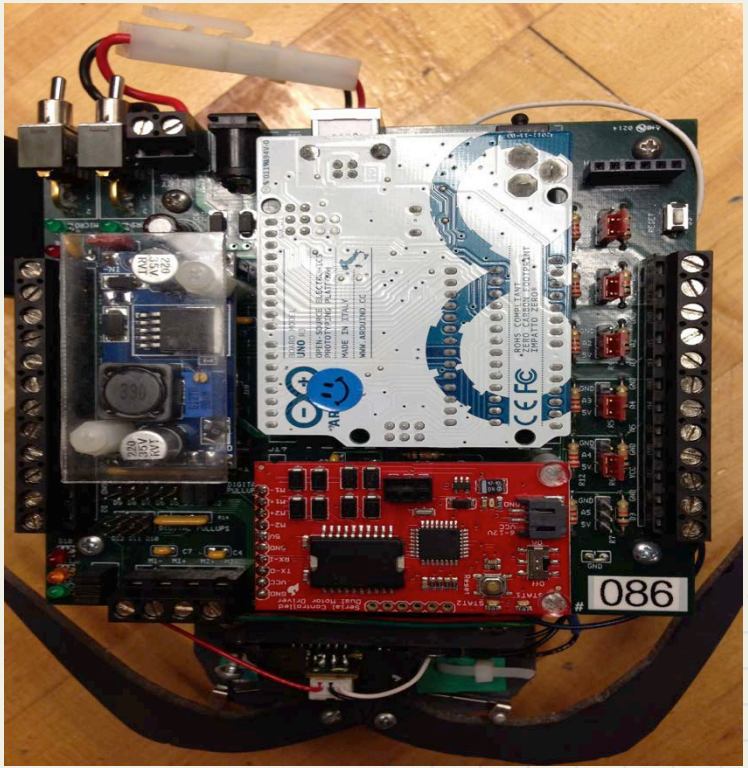
- Claws
  - 2 Bumper Switches on Left and Right side of robot
  - Pointy, Front-Split Bumpers
  - 3 Target Light Sensors
    - Left, Right, and Rear of robot
  - 1 Beacon Light Sensor
    - Placed on center platform
    - 3 inches above robot



		Claws	
Number of Bumpers		2 Bumpers	
Shape of Bumpers		Pointy - Front Split	
Placement of Bumper Switches		On Body	
Number of Target Light Sensors		3: 2Front, 1Rear	
Height of Beacon Sensor		3 in. above roof	
Any other parameter you think is important			
Acceptance Criteria	Weight (by %) of Acceptance Criteria (apply last)	Importance of Conceptual Design in meeting Acceptance Criteria	Weighted Score
Teams chose own acceptance criteria			
competitions)	5	5	25
Doesn't confuse the navigation light with target lights	15	5	75
Minimal Impact on software complexity	15	5	75
Crosses from Friendly to Enemy Territory in 15 seconds	10	4	40
seconds	25	5	125
After crossing over, the sub system detects light 1 and extinguishes it. Then it detects light 2 and extinguishes it.	20	5	100
Doesn't cross back to friendly territory after crossing into enemy territory	10	3	30
Total Percentage =	100%		470

Electrical System

- Specific Port Configuration
- Floor Sensor Module (FSM)
- Target Light Sensors
- Beacon Light sensors



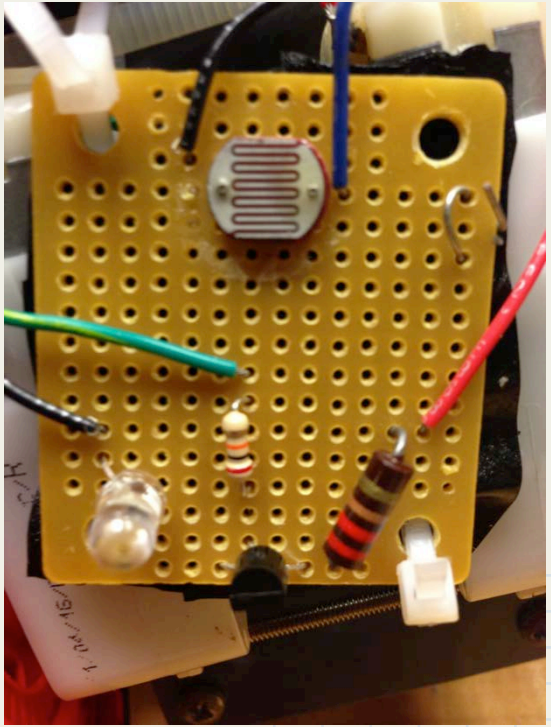
Specific Port Configuration

- A1 - Left Target Light Sensor
- A2 - Right Target Light Sensor
- A3 - Floor Sensor Module
- A4 - Navigation Light
- A5 - Middle Target Light Sensor

- D2 - Right Bumper Switch
- D3 - Left Bumper Switch
- D4 - White LED
- D10 - Red LED
- D11 - Yellow LED
- D12 - Green LED
- M1- - Motor 1
- M1+ - Motor 1
- M2- - Motor 2
- M2+ - Motor 2

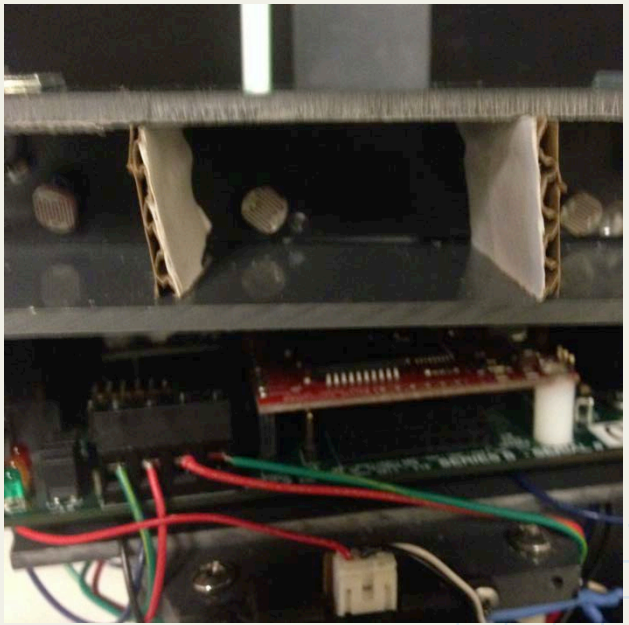
Floor Sensor Module

- Reads and records voltage measured by ground color
  - Allows robot to distinguish between “home” and “enemy” territory
- Mounted to bottom of robot



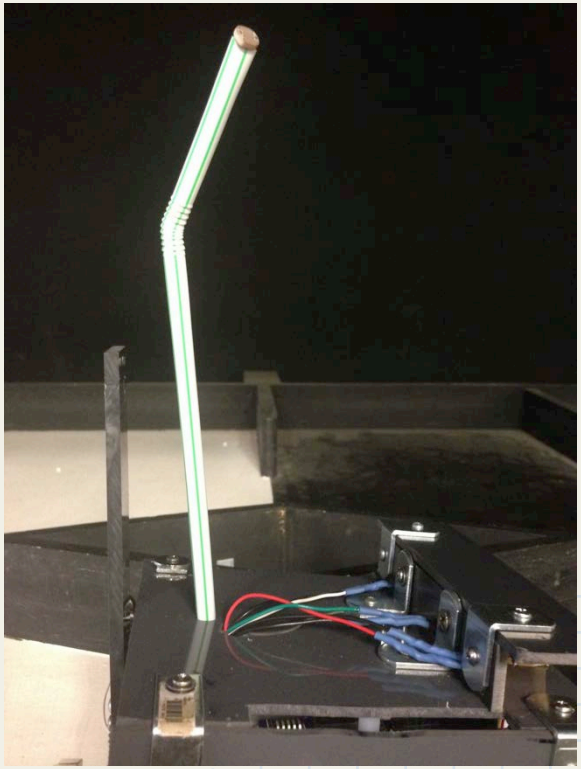
Target Light Sensors

- 3 Sensors
  - Left, Center, Right
  - 3 sensors detect directionality of Target Lights
- Separators put between each sensor



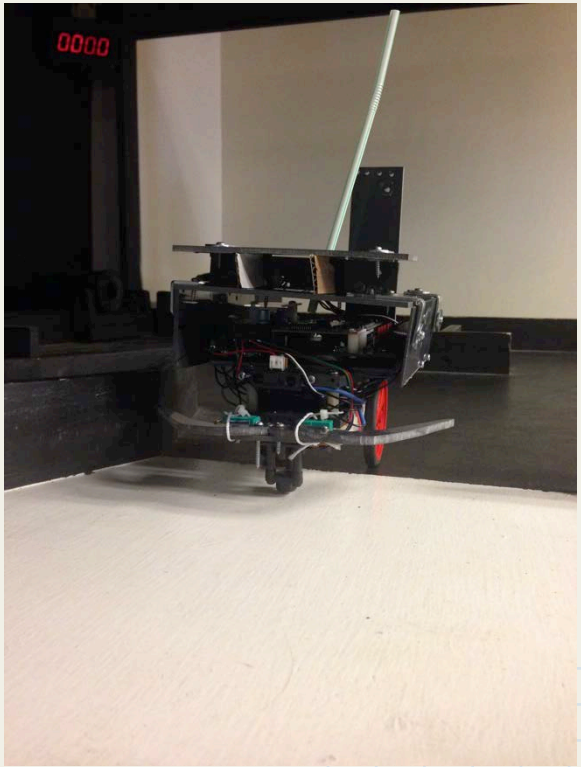
Beacon Light Sensor

- 6 inches above platform
- Run through a straw
- Angled diagonally
  - Increases its accuracy at finding the beacon light



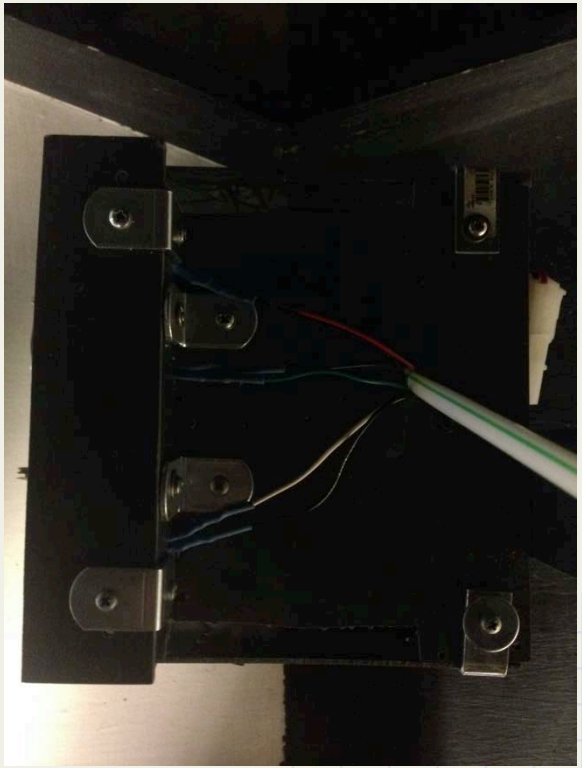
Mechanical System

- Body Structure
- Bumpers
- Motors
  - Speed
  - Direction



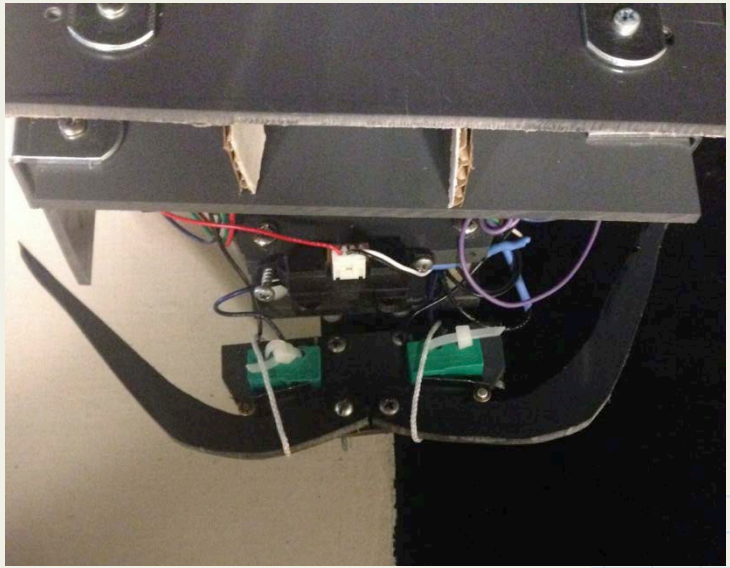
Body Structure

- Constructed with Plastic
  - Flat Platform
  - Pillars for Platform
  - Bumper Extension
  - Target Light Sensor Covering
- Connected by screws



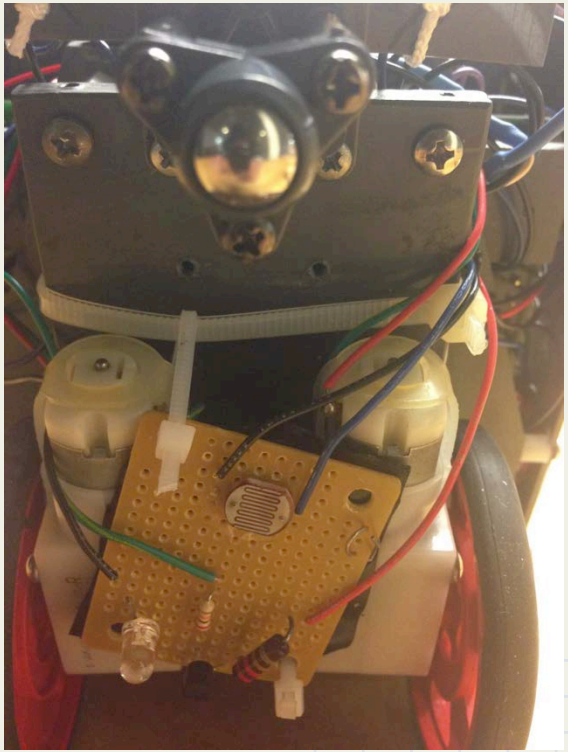
Bumpers

- Hook-shaped
  - Left and Right bumper
  - Mounted on flat platform
- Bumpers wrapped with strings
  - Prevents excess movement
- Positioned diagonally
- Bumper switches
  - Behind left and right bumpers



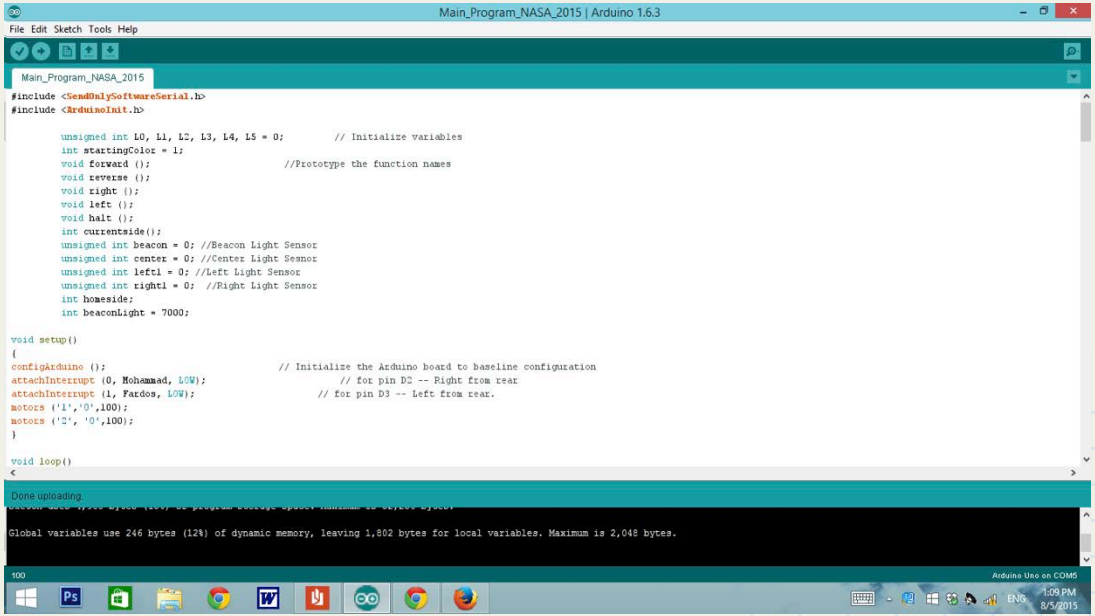
Motor: Speed and Direction

- Speed and Direction both calibrated by Robot Dance
  - Code that programs robot to move in various directions

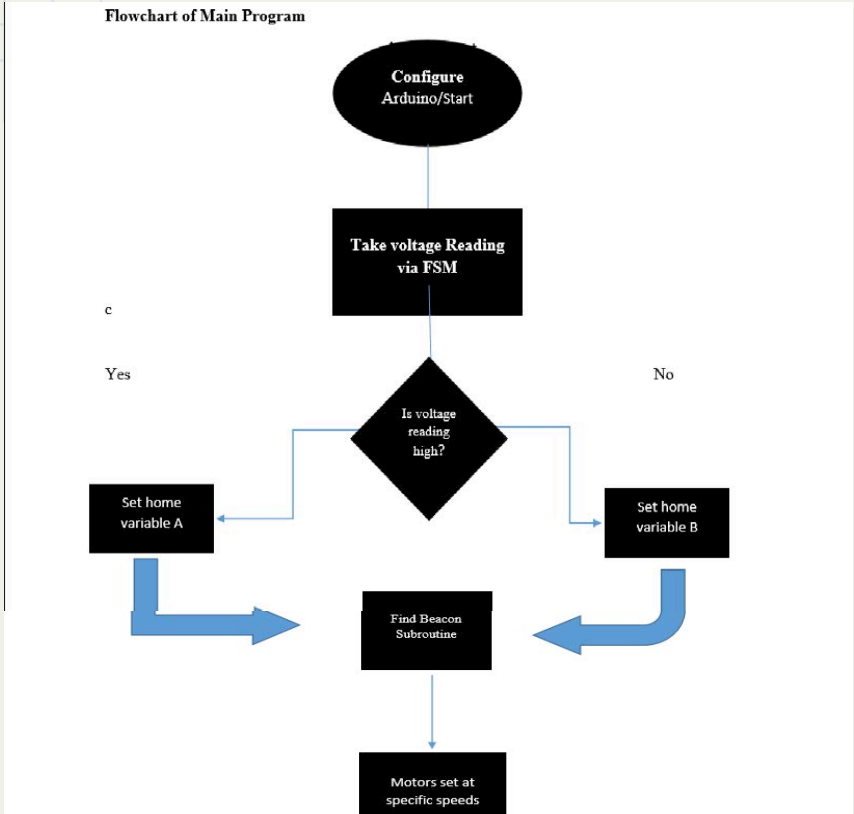


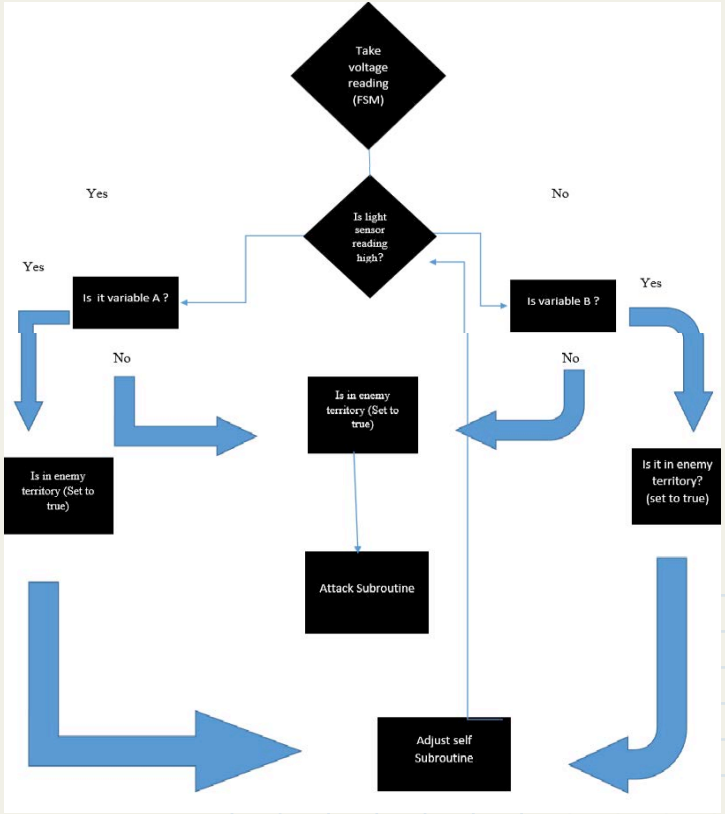
Software

- Subroutines
- Light Sensor Calibration
- Integrated Development Environment (IDE)



Flowchart


Flowchart of Main Program
Configure Arduino/Start
Take voltage Reading via FSM
c
Yes
No
Is voltage reading high?
Set home variable A
Set home variable B
Find Beacon Subroutine
Motors set at specific speeds


Take voltage reading (FSM)
Yes
No
Is light sensor reading high?
Yes
Is it variable A ?
Is variable B ?
Yes
No
No
Is in enemy territory (Set to true)
Is in enemy territory (Set to true)
Is it in enemy territory? (set to true)
Attack Subroutine
Adjust self Subroutine

Subroutines

- Forward
- Reverse
- Left
- Right
- Halt

Light Sensor Calibration

- Robot placed in various areas in arena
  - Light sensors were calibrated to take voltage readings

- Calibration data used as a comparison for programming the robot

```
A0: 44737
A1: 44688
A2: 41111
A3: 29939
A4: 24598
A5: 42385

A0: 44149
A1: 44639
A2: 41062
A3: 29890
A4: 24696
A5: 42434

A0: 45178
A1: 44541
A2: 41013
A3: 29841
A4: 24255
A5: 42189

A0: 44149
A1: 45031
A2: 40817
A3: 29792
A4: 24010
A5: 42140

A0: 44296
A1: 44394
A2: 40866
A3: 29841
A4: 24059
A5: 42091
```

Integrated Development Environment (IDE)

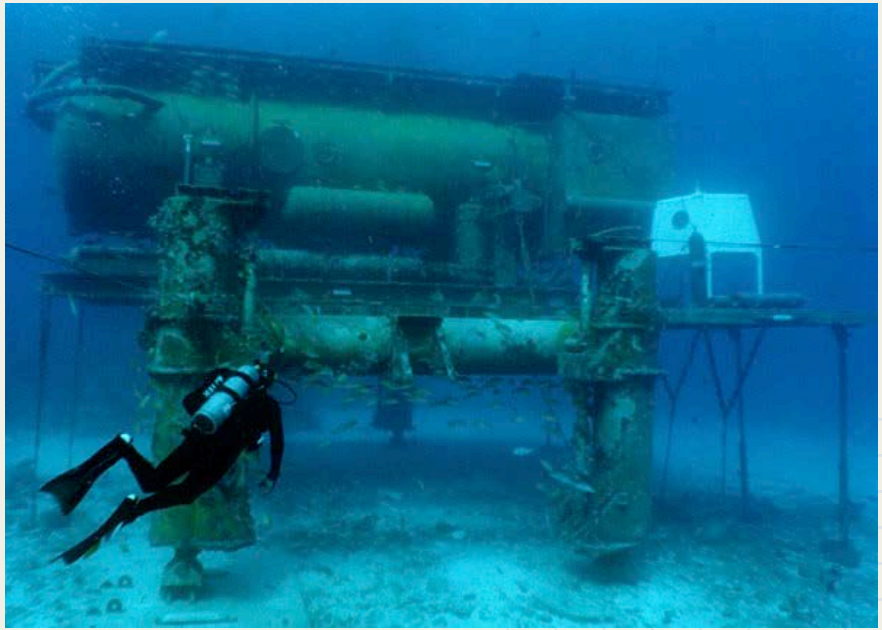
- Arduino
- Code is created, compiled, and executed
  - Written in C++
- Software libraries
  - Defined functions
  - Contains code that help with main objective

RAVEN

- Surgical Autonomous Robot
- Possibility of being put to use at the ISS
- Laparoscopic Surgery
- Displaces need for surgeon in room for surgery to be successful

NEEMO MISSION 12

- NASA Extreme Environment Mission Operations 12 Mission
- May 7-18, 2007
- Two surgical robots deployed to Aquarius Underwater Lab
  - RAVEN and SRI
- Goal was to examine RAVEN's capability to assist astronauts in healthcare during extended space missions



Acknowledgements

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- NASA Goddard Institute for Space Studies (GISS)
- NASA New York City Research Initiative (NYCRI)
- Stevens Institute of Technology (SIT)

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